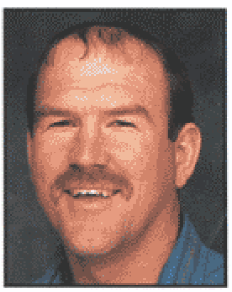
BENTLY ROTOR DYNAMICS RESEARCH CORPORATION

Shaft CenterLINES

Monitoring versus diagnostics

Why do peak readings differ?



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Monitoring and diagnostic equipment will sometimes read differently when measuring the peak value of complex waveforms associated with machinery vibration. Knowing how the vibration signal's peak amplitude is measured can give you a better understanding of why there are differences and how they are applied for your benefit.

Let's first define the basic vibration measurement units we will be discussing.

Peak-to-peak, zero-to-peak and true peak

When monitoring radial vibration with proximity probes, peak-to-peak is defined as the total movement of the shaft in a single plane. **When seismic transducers are used to measure acceleration or velocity, Bently Nevada strongly recommends use of the zero-to-peak measurement because it is more effective and easier to interpret**. Bently Nevada defines zero-to-peak as the peak-to-peak value of a vibration signal divided by two. At Bently Nevada, zero-to-peak is synonymous with true peak. (Figure 1).

Derived peak

Some instruments divide a measured RMS value by 0.707 in order to get a peak (or ultimately peak-to-peak) value. **The result, called "derived peak," is misleading and is not recommended because it is only accurate for a sine wave.** There is no scalar relationship between peak and RMS values that applies to all waveforms. For instance, the RMS value of a square wave is 1.0, and of a triangle wave is 0.577. Typically a vibration signal is not a sine wave, but rather a complex combination of several different waveforms.

Peak detectors, a closer look

All zero-to-peak (true peak) and peak-to-peak detectors have fundamental performance factors that affect their ability to respond to various input waveforms. These performance factors are the same whether the circuit is analog or digital in nature and regardless of whether the circuit displays peak-to-peak or zero-to-peak.

Bently Nevada has developed two basic types of peak-to-peak detectors during the 38 years it has measured vibration. One type of peak-to-peak detector is used in monitoring systems, such as the 3300 System. A second type of detector is used in diagnostic instruments, such as the Digital Vector Filter 2 & 3, 108 Data Acquisition Instrument and the 208 Data Acquisition Interface Unit. These different detectors are used because of the different uses of the instruments.

There is no difference in the measurement of peak-to-peak between a Bently Nevada Monitor and a diagnostic instrument (within the instrument's fre- ►

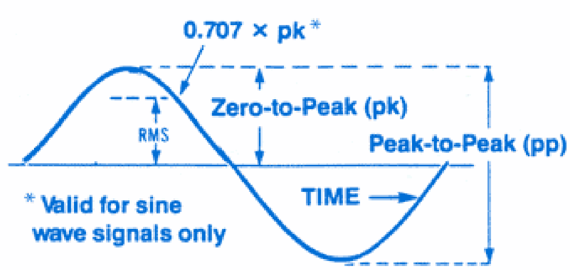

Figure 1

quency response) when the two types of instruments are measuring waveforms, such as square, sine and triangle waveforms. In fact, this characteristic can be used to determine whether an instrument displays a true or a derived peak amplitude value. Input each waveform with the same peak-to-peak value from a signal generator (check it with an oscilloscope.) Make sure the frequency content of the signal falls within the bandwidth of the instrument. If the instrument's peak (or peak-to-peak) value does not change as you switch waveforms, then it is measuring a true peak value (see Note 1). The chief differences are exhibited when the two types of instruments process waveforms with transient noise or complex frequency content.

Monitor peak-to-peak detectors

Bently Nevada monitors have evolved to provide extremely reliable machine monitoring. This has led to a design that minimizes susceptibility to noise, while providing the peak-to-peak function. Originally achieved by using diode-based analog circuits, these circuits now use a combination of analog and digital technology. Although the technology has evolved, the circuit's response has been maintained so it is consistent with older Bently Nevada monitors (Figure 2).

Bently Nevada 7200 and 3300 Monitors continually process the incoming signal. The peak-to-peak circuit output is constantly adjusted based on the instantaneous value of the incoming signal and the circuit's memory of past peaks. When the input signal exceeds the circuit's memory of past peaks, the peak-to-peak detector increases the peak-to-peak value. We describe this as charging. When the input signal is less than the current memory of the past peaks, the peak value decreases. We call this discharging.

Charging

When the input signal exceeds the prior peak value, the peak-to-peak detector charges the peak capacitor. Early analog circuits limited the rate at which the peak capacitor was charged. This rate allows the peak-to-peak detector to "respond" to the new peak at a rate of approximately 5% of the instrument's full scale value per millisecond. This controlled charge rate has the added benefit of reducing the peak-to-peak detector's response to transient

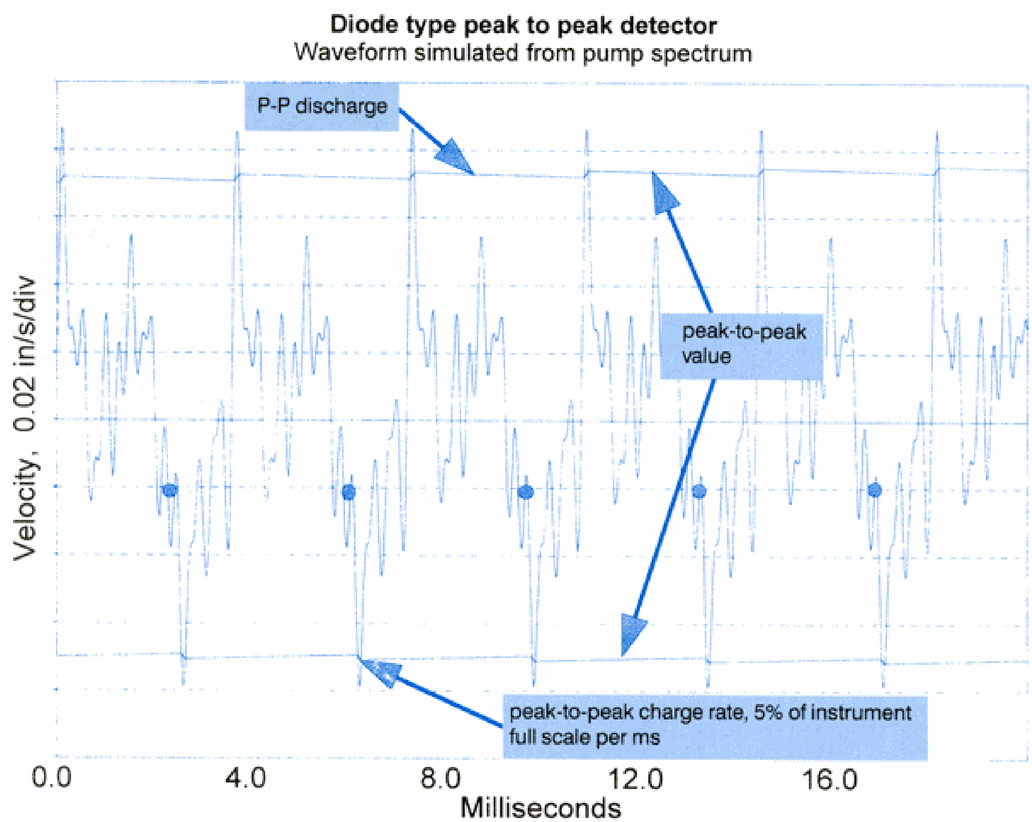

Figure 2
Monitor type peak-to-peak detector

Note 1. *The response of instruments may vary with square and triangle waves when the entire signal conditioning path is considered. For example, high and low-pass filters can distort square and triangle waves, causing changes in the peak-to-peak waveform and readings.*

and high frequency noise. Because of the design's success, we haven't changed the circuit's charging rate even though advancements in electronics make it technically feasible.

A result of this controlled charging rate is that frequencies with periods of less than 1 millisecond require multiple cycles to charge the detector to the input peak-to-peak value. For example, the peak-to-peak detector would require approximately 20 cycles to charge to within 1% of its final value if the input were a 1 kHz sine wave.

Discharging

If the input signal goes to zero, the peak value will discharge to zero after a certain period of time. The time it takes the circuit to discharge to within 37% of its final value is described as the discharge time constant. Monitoring circuits use two different discharge time constants. The first discharge time constant is the more common. It is used on all monitors optioned for use with seismic transducers and on radial vibration monitors with a low pass frequency response of 240 cpm. This time constant is approximately 1 second.

A longer time constant of 4 seconds is only used on radial vibration monitors with a low frequency response of 60 cpm for very low speed machines. This time constant allows the peak-to-peak detector to remember past peaks for a longer time period.

Diagnostic instrument peak-to-peak detector response

Bently Nevada's diagnostic instruments calculate peak-to-peak with results equal to what would be seen on an oscilloscope. This type of detector's performance has evolved with technology, producing faster and more accurate detectors. The goal is to track all information in a transducer signal, regardless of its origin.

This type of instrument samples the input for a specific time or for a set number of shaft rotations. It takes a "snapshot" of the signal during this time period, in contrast to the monitor which is constantly providing a value proportional to the current input based on the past inputs. The diagnostic instrument

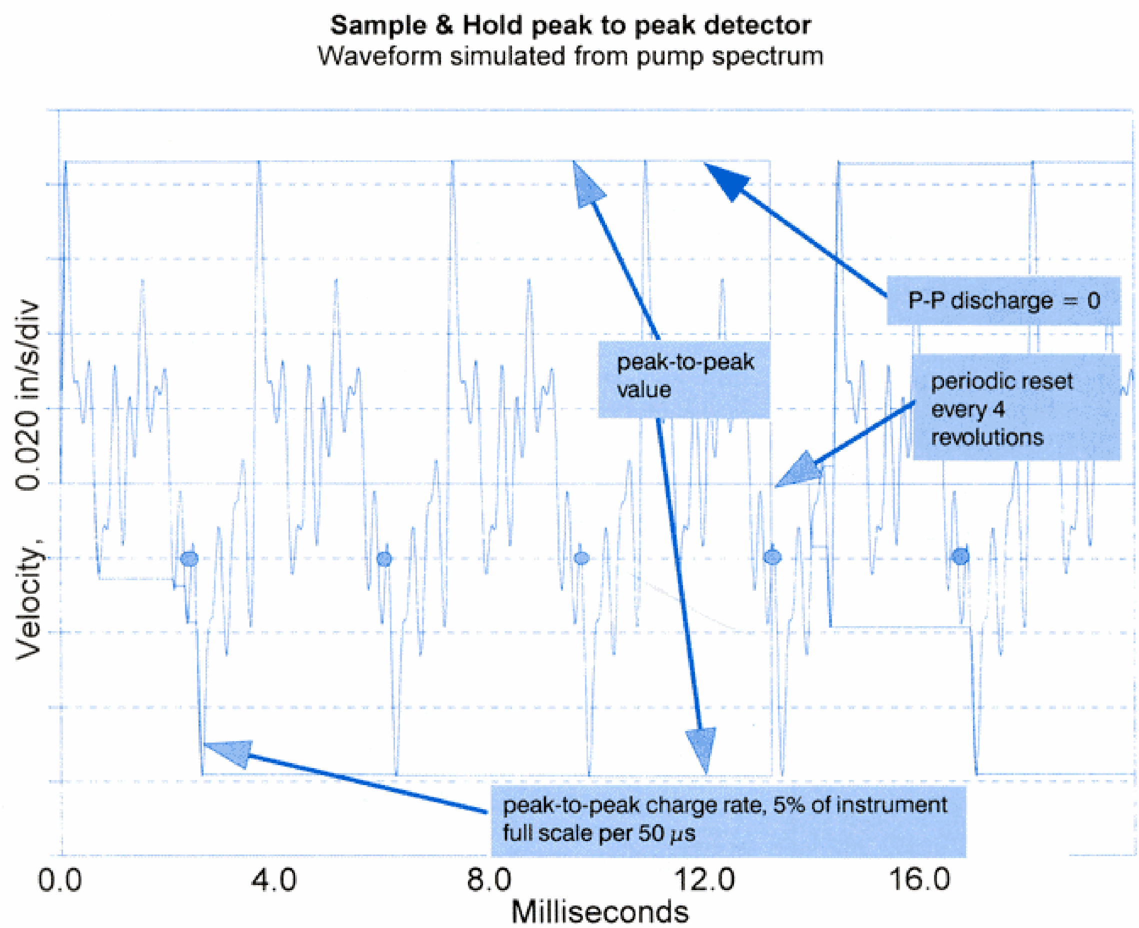

Figure 3
Diagnostic type peak-to-peak detector

works very differently during its charge and discharge cycles.

During its charge cycle, the diagnostic instrument's peak-to-peak detector charges much faster than the monitor's detector. Typically, a diagnostic instrument's peak-to-peak detector charges at a rate of 5% of full-scale in 50 microseconds, 20 times faster than a monitor's detector. This makes the detector very responsive to most signals.

During the discharge cycle, the discharge of its peak-to-peak detector is at a set interval or is triggered by the Keyphasor®. The peak-to-peak value discharges in a few microseconds, prior to each new snapshot of the input signal (Figure 3).

Conclusion

When reading complex waveforms, the monitor and diagnostic instrument's peak-to-peak values will differ by small amounts. These readings vary because of the different applications each instrument is intended for. The monitor peak-to-peak detector's reduced response to higher-order frequency content and transient noise makes it very useful for reliable machinery monitoring. Diagnostic instruments need a broadband high-speed response to capture as much information from the signal as possible, to provide a machinery diagnostics engineer with the data necessary to diagnose machinery and instrumentation faults. ■